(11.)

A DESCRIPTION

OF

THE DIPLEIDOSCOPE,

OR

DOUBLE-REFLECTING MERIDIAN AND ALTITUDE INSTRUMENT;

WITH

PLAIN INSTRUCTIONS FOR THE METHOD OF USING IT IN THE CORRECTION OF TIME-KEEPERS.

BY

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BY SPECIAL APPOINTMENT

CHRONOMETER AND CLOCK MAKER IN ORDINARY TO HER MAJESTY THE QUEEN, HIS ROYAL HIGHNESS PRINCE ALBERT, AND H.I.M. THE EMPEROR OF RUSSIA.

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CONTENTS.

	PAGE
Preliminary Remarks	5
Use and Importance of the Dipleidoscope	6, 7
Explanation of the Optical Construction of the Instrument	7, 8
Familiar Elucidation of its Effects	8, 9
Different form of Mounting	10
Proper Situations for Placing, &c.	10, 11
Method of Placing, and Directions for Testing	12, 13, 14
Explanation of the Terms Apparent and Mean Noon	13
Other Methods of Placing the Dipleidoscope	13, 14
Directions for Taking Observations	15
Observations	16
Remarks when the Instrument is required for India	17
Effect of Longitude on Time	17
Postscript	18, 19
Dent's Approximate Table of Longitude in Time	20, 21
——— Table for the Equation of Time	22, 23
Table of the Sun's Semidiameter	24

ILLUSTRATION OF THE SIMPLE MODE OF TAKING AN OBSERVATION WITH THE DIPLEIDOSCOPE.

DENT

ON

THE DIPLEIDOSCOPE.

PRELIMINARY REMARKS.

"The time," in popular language, denotes a certain division of the day, calculated from the Sun's appearing at its greatest or meridian altitude at any particular place.

When the Sun has reached this altitude, it is mid-day, or noon.

The day, that is the time occupied by the Earth in making one complete revolution upon its axis, is divided into twenty-four parts, or hours.

In the course of this revolution, every part of the earth's surface must have been directly opposite to the Sun; or, in language more scientifically correct, must have had the Sun in the plane of its meridian: and the moment at which any particular place was thus directly opposite to the Sun, was noon to the inhabitants of that place.

Hence it will be seen, that the word "noon" is a relative term, and that of any two places situate in different longitudes, noon will be earlier at the place which lies nearer to the east. If the distance be fifteen degrees of longitude, the difference will be one hour; and so more or less in proportion.

The revolution of the hands of the clock is intended to be a faithful index of the revolution of the Earth on its axis; and, to a certain extent, is so: but the imperfection of all human workmanship renders even the most exquisite machinery liable to error. This error can be corrected only by actual observation of the heavenly bodies.

These observations are continually being made by our principal astronomers at different observatories; and the time is either communicated to the public by means of a signal—*the falling of a large ball*, that may be seen from a considerable distance—or by printed tables and other methods.

Chronometer-makers of any eminence have usually an observatory of their own, with the apparatus requisite for ascertaining the true time for themselves. The expense and labour attending such arrangements have hitherto placed it out of the power of the ordinary watch-maker to take his own astronomical observations; a difficulty which, at the trifling expense of two guineas, will be removed by the instrument below described.

The Dipleidoscope, or new patent meridian-instrument, will enable any person to obtain correct time with the greatest facility, by an observation either of the transit of the sun over the meridian by day, or of the transit of the stars by night. In the following explanation, however, it is intended, for the sake of consulting both brevity and simplicity, to confine the directions to solar observation.

This new instrument possesses great advantages over any other of similar correctness; it is exceedingly simple, it is not liable to get out of adjustment or repair, and it does not require any attention beyond that which is, of course, necessary in the first instance, viz.: that it be placed on a level surface, and in the meridian. The observations to be taken afterwards, can be made by any one, although previously unacquainted either with astronomical apparatus or practical astronomy; the instrument being as simple as a sun-dial, while it is infinitely more correct, since it gives the time to within a fraction of a second. The utility of possessing an indicator of this kind in addition to the most perfect time-keeper, must be evident; for, however excellent a clock or watch may be, experience shows how difficult it is to obtain exact time, *for lengthened periods*, by any mere mechanical contrivance. To remedy the defect of mechanism, it has been already remarked, that actual observation of the heavenly bodies becomes indispensable; as, without it, the best time-keeper cannot be implicitly depended upon for any considerable interval. On the importance of exactness in this essential matter, it is not necessary to enlarge: it will suffice merely to allude to the inconvenience of missing a railway train. An advantage also not to be overlooked, is the gratification of knowing, especially in remote parts of the country, that you are in possession of the true time; information which is now not easily to be obtained: for it is notorious on what uncertain contingencies the regulation of the parish clock, in many of our rural districts, continually depends;—such as the passing of some public vehicle, or the announcement of the guard of a mail-coach.

Perhaps, then, it is not saying too much to affirm, that a Dipleidoscope should be placed in all country Parsonages, as well as in Railway stations, and government establishments, both at home and abroad.

EXPLANATION OF THE OPTICAL CONSTRUCTION OF THE INSTRUMENT.

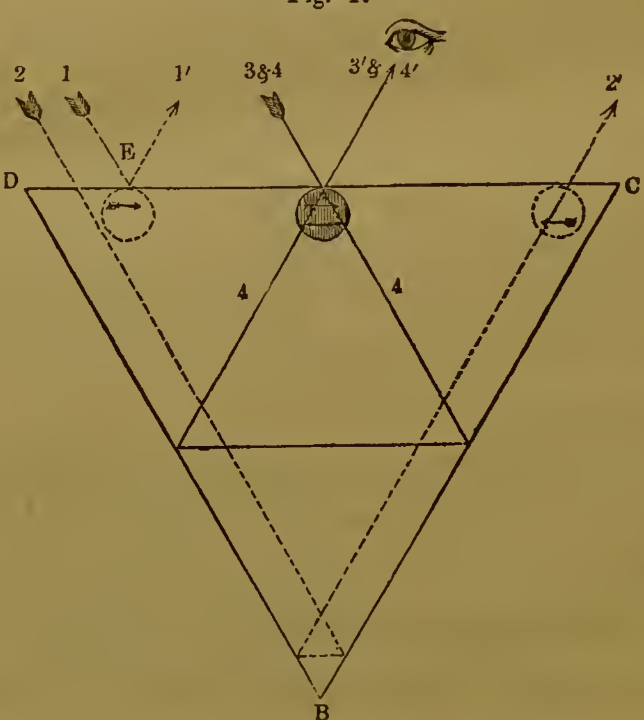
The following explanation being designed for popular use, scientific language has been avoided, as much as practicable. It is impossible, however, that a philosophical instrument can be made familiar to the general reader, without some reference to philosophical principles, which the writer will therefore be excused from stating in this place, as an important and indispensable preliminary.

In the language of philosophy, the law which governs the transmission of light is, that the angle of the rays of incidence is equal to the angle of the rays of reflection. In other words, supposing the rays of light proceeding from an object to fall upon a reflecting plane, the eye of the observer must, in order to see the reflected image of that object be so placed that the rays reflected to his eye from the plane may form the same angle with it as the rays proceeding from the object to the plane. The rays falling upon the plane from the object are called "the incident rays;" as the rays again proceeding from the plane to the eye are termed the "reflected rays."

Keeping this law or principle in view, let us next consider the construction of the reflecting planes of the instrument in question:—

There are three reflecting planes, D C, D B, and B C. fig. 1. Suppose D C to be so divided that the ray, No. 1, falling on D C, at E, will be reflected to the eye at 1′, and the image of the sun will appear to advance in the direction from D towards C. The ray, No. 2, passing through D C, is reflected from C B, impinges on D B, and reaches the eye in the direction 2′. The image of the sun thus formed will appear to move from C towards D, because it has been *twice* reflected, and thus the two images will *approach* each other. Suppose the ray No. 1 to have advanced to the position No. 3, and the ray No. 2 to the position No. 4; it will then be evident that their reflected rays will be in the same direction 3′ and 4′, and, therefore, that the two images of the sun coincide, as shown by the arrows being in the position of crossing each other, and indicating the instant of apparent noon; as the rays continue to advance, the images, having passed over each other, will, of course, be seen to separate.

Fig. 1.

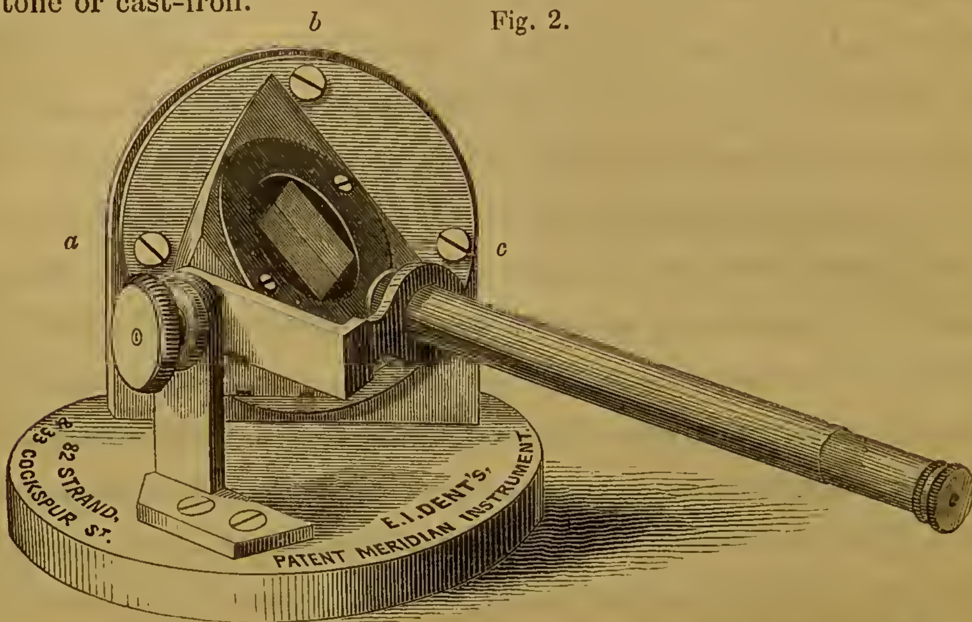


The following familiar illustration is introduced to further explain the optical construction. When the sun is about setting, it is not uncommon to see the rays so reflected from the windows of a whole range of houses, as to convey the idea of a public illumination. While some portions of the sun's rays are thus reflected, other portions pass through the glass into the rooms. The rays thus transmitted (the rays of *incidence*, as they were styled above) may be reflected at pleasure in any direction consistent with the range of the sun, by a person within the room, having a looking-glass in his hand. Now if, instead of throwing the rays upon a non-reflecting object (such as the wall, &c.), he were to transfer them to another looking-glass, they would be again reflected from this latter glass. Supposing these two looking-glasses to be placed at an angle of less than 90°, in a manner corresponding with the position of the two silvered planes seen in the instrument, and also shown in the diagram at D B, B C, he can reflect the sun's rays again out of the window. Now, if we imagine the window to represent the outer reflector of the meridian-instrument, its construction is, by this process, completely exemplified. To proceed a little further; it is evident that the angle and situation of the two looking-glasses could be so arranged as to direct the rays of the sun through any particular pane of the window; so that a person standing without, in a proper position, would see, in addition to the sun's rays reflected from the *outer* surface of the pane, the rays of incidence that had passed through the window, and were thus reflected from the double mirror. One of the luminous objects (the flash or glare of the sun) so produced, would be reflected from the surface of the window, and would be a *single* reflection; while the rays of incidence, which had passed through the window, and undergone a *double* reflection by means of the *two* mirrors would, on being thrown back by the mirrors through the window, move in a direction contrary to that taken by the single reflection from the surface of the window-pane. Hence, any one of the heavenly bodies, subjected to the eye by a process of the above description, would not only appear as two distinct objects, but those objects would be seen to approximate and cross each other in an *opposite* course: a desideratum being hereby secured which increases the power of the instrument in a double ratio, and renders it proportionably preferable to any other that has been hitherto employed.

It may not be amiss to add, that the experimenter who is desirous of making the observation with the utmost possible accuracy, may, after protecting his eye with th darkened glass, employ a telescope to magnify the object in the field of view.

Fig. 2, represents a Dipleidoscope fitted up with a telescope, and having all the usual meridian and vertical adjustments, to be effected by means of the screws, *a*, *b*, *c*. This form of mounting the instrument is suited to the observatory or library, where it should be placed on a pedestal of stone or cast-iron.

Fig. 2.



The situations well calculated for setting up the instrument are so various that it would be impossible to enumerate them: two of the most usual may however be mentioned.

Fig. 3, exhibits the Dipleidoscope placed outside a window, on the stone ledge.

Fig. 3.

Fig 4, shows the instrument fixed on a pedestal in the open air; for as by the workmanship it is impervious to the weather, the instrument needs no further protection than the brass covering with which it is supplied.

Fig. 4.

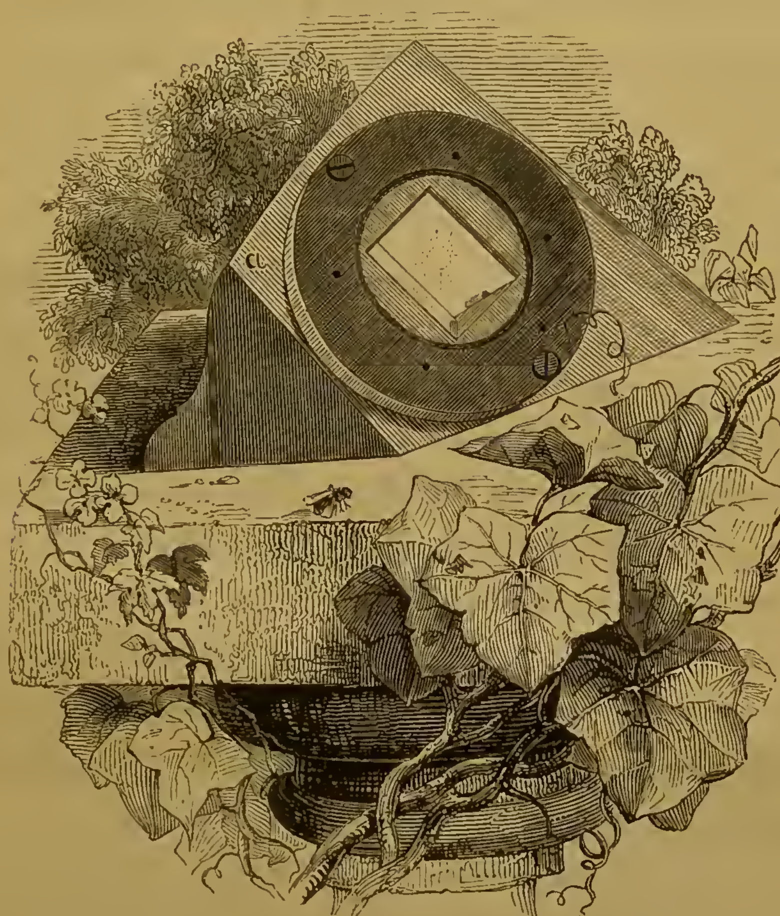


Fig. 5, represents a darkened glass, covered by a film of smoke, which will protect the eye from the varying lustre of the sun's rays occasioned by thin clouds, by using different portions of the glass, according as they are more or less transparent.

Fig. 5.

METHOD OF PLACING THE DIPLEIDOSCOPE, AND DIRECTIONS FOR TESTING.

To illustrate and explain the method of placing the Dipleidoscope in the meridian, let us suppose the place of residence to be Dover. The longitude of the abode, in time, having been ascertained by reference to the ordnance-map, a good watch or chronometer, set to the time of the spot, is to be taken for the standard; and on the following day (or as soon after as the sun will permit), let us suppose the instrument is to be fixed. After it has been placed on a previously levelled surface, the following preparatory practice may be gone through, commencing about two hours before noon. Place the instrument on the unwrought end, with its two flat sides in the direction of the sun's rays: a sheet of paper may now be held nearly opposite the front glass, at about two feet distance (care being taken not to obstruct the rays of the sun from passing into the instrument), when the reflected image from the front glass will immediately be thrown upon the paper. The instrument should then be gently turned either to the right or left, until *another* similar image appear on the paper; these will mutually approach, until one is seen to cover the other, and they appear as one. If the observer then looks into the instrument (having the lowest side *a* (fig. 4) always towards him, and his eye protected by means of the darkened glass), he will perceive the sun reflected in it, as one luminous circular object. The principal advantage derived from previously throwing the images on the paper is, that it indicates to the observer the direction in which he is to look into the instrument. By keeping his eye upon the sun, as exhibited in the glass, he will, after the interval of a few moments, perceive a *second* sun appear to pass away from the former:—these will presently be entirely detached, and two distinct suns will be seen. If he turn the instrument very gradually towards the west, the images may be so regulated as to re-approach, coincide, and separate again; and thus afford the opportunity of practising the complete observation described at pages 15 and 16. This experiment may be repeated at the pleasure of the observer, until he feels he has acquired the requisite skill for the permanent fixing of the Dipleidoscope; which, it needs hardly be remarked, must be effected at apparent, or solar noon.

Before proceeding to the example intended to show the manner of placing the instrument in the meridian, it should be premised, that the twelve o'clock exhibited by the watch or chronometer designates what is called *mean* noon; so styled to distinguish it from apparent noon. Between mean and apparent noon there always exists a difference, *owing to the variation of the earth's motion in its course through the ecliptic*, and to the obliquity of this to the plane of the equator. The provision made by astronomers to meet this inequality, and to reduce apparent time into mean time, (which latter clocks and watches indicate,) must be familiar to every one who is acquainted with the pages of an almanac. Scientifically speaking, this reduction is called the *equation of time;* and its application is indicated in the ordinary almanac by the phrase "clock fast," or "clock slow," accompanying the table.

All the preparatory steps above alluded to having been taken, the instrument is now to be permanently fixed; which process, for the clearer elucidation of the matter, we will suppose to take place on the 2nd of October. The criterion for determining the position of the Dipleidoscope is, that the two images must coincide, or appear as one, when the chronometer shows, according to the equation table, 11 h. 49 m. 30·1 s. It may be concluded that the instrument is then correctly in the meridian. If, however, on a subsequent trial, the chronometer, which we have taken as the standard for fixing the Dipleidoscope, makes the time shown by it too fast, the front glass must be moved, with great care and nicety, towards the east; if slow, with similar caution, towards the west.

It must be observed that the equation of time table contains a calculation for every day in the year; as the example given at the head of the table shows. When the Dipleidoscope is to be fixed, the suns must coincide at the time stated in the table for mean noon on the day in question, whatever time of the year it may be.

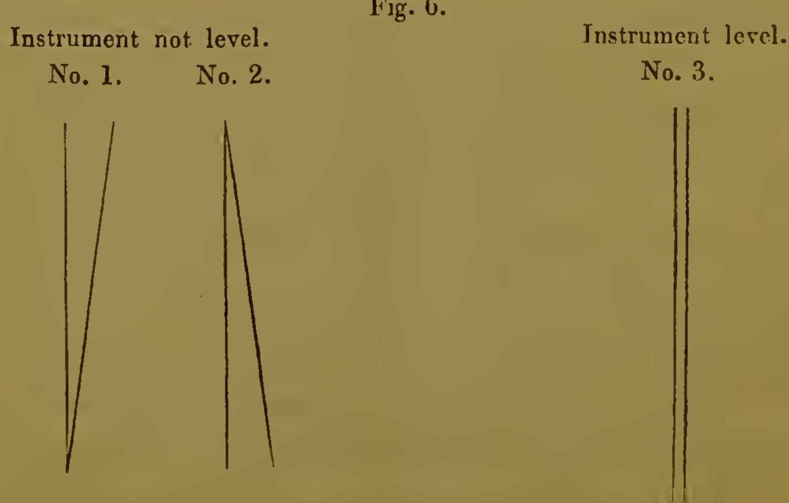
There is also another manner of placing the instrument in the meridian, although not by any means so correct or so easy as the former. It is that usually employed in fixing an ordinary sun-dial. Set a mariner's compass on the spot where the Dipleidoscope is to be fixed, and having obtained the quantity due to the magnetic variation of the place, suspend a plumb-line in the astronomical meridian. The compass is then to be removed, and the Dipleidoscope put down in its room. The apparently two plumb-lines, reflected in the instrument, must, by turning it gently round, be brought together, so as to coincide and appear as one; precisely as the two suns, in the following example, page 15, fig. 7, are brought into union.

A third and more perfect way of fixing the instrument may be derived from observation of the pole-star; but as this process involves some knowledge of practical astronomy, it is little adapted to general practice.

Having above detailed the method of fixing the Dipleidoscope in the meridian by means of the chronometer, &c. let us now proceed to describe the manner of testing its adjustment, and to give an example of the observations necessary to be taken.

In order to prove that the instrument is placed correctly, the observer must hang up a plumb-line, made of small white thread, at about two feet distant from the front glass, and move the line to the east or west, until the two lines reflected coincide in the field of vision. If the wind be high, so as to agitate the line, it will be requisite to immerse the plumb in a cup of water. Should the Dipleidoscope not be level, it will exhibit the images of the plumb-line diverging from each other, either at the top or bottom; as indicated at Nos. 1 and 2, fig. 6. To remedy this, a small piece of thin metal must be introduced under one of the sides which run parallel with the sun's rays, and the instrument must be adjusted according to circumstances, until the images of the plumb-line become parallel; as seen at No. 3. Correctness in this matter is of the

Fig. 6.



utmost importance; for if the instrument be not fixed correctly, the variation in the sun's altitude in summer and winter will occasion the Dipleidoscope to vary its indication of time.

The Dipleidoscope, when the level has been thus ascertained, must be firmly cemented.*

DIRECTIONS FOR TAKING OBSERVATIONS.

The instrument being supposed to be placed properly in the meridian, we may now notice the manner of completing future observations:—The reflection of two suns can be seen in the field of view for about ten minutes before their edges touch each other; and the complete observation consists in their movements being noted by the watch or chronometer at three separate times. First, at the contact or touching of the two limbs or edges; secondly, when the suns exactly coincide; and thirdly, when the edges separate; as is shown by the following diagram—

Fig. 7.

1st Observation. 2nd Observation. 3rd Observation.]

But as the interposition of clouds may sometimes frustrate one or two of the observations, it becomes important to provide a remedy for such accidents. This is done by a calculation of the amount in time of the passage of the sun's diameter, with reference to the observation that happens to have been secured. If, for instance, the first observation be lost, and the second obtained, the loss is not of importance with regard to the

* To any gentleman who may be disinclined to take the trouble of fixing the Dipleidoscope for himself, and who is desirous of securing the utmost possible accuracy, Mr. Dent will send a competent person, furnished with a chronometer, to fix the instrument, on payment of the actual travelling expenses, and a remuneration to the party of ten shillings per day.

second, as that observation is complete in itself—the sun's place on the meridian being ascertained by the coincidence of the images. If the second observation be lost, and the first only obtained, *add* to the time then shown by the chronometer the amount of the passage of the sun's semidiameter, which will be found in the proper table at the end of this book. For those with whom strict astronomical precision is not so much an object, it is sufficient to say, that the quantity of 1 m. 7 s. may be used as the mean for the sun's semidiameter throughout the year. If both the first and second observations be lost, and the third only secured, *subtract* from the quantity shown by the chronometer the sun's semidiameter, and the requisite time is obtained.

For the sake of example, the following observations for 1843 are annexed; but when required for any succeeding year, the times must be taken from the Equation-table for the year required, and which accompanies this book:—when the one bound up is past the year, succeeding Equation-tables can be had if applied for by letter.

OBSERVATIONS.

1843, *October* 2. *Time shown by Watch or Chronometer.*

		H.	M.	S.	
1st Observation . .		11	48	25·5	
2nd ditto . . .		11	49	30·1	
3rd ditto . . .		11	50	34·7	
	2)	23	39	0·2	The first and third added together.
		11	49	30·1	Mean.

Further to illustrate the use of the above example, suppose the 2nd and 3rd observations to have been lost, and the 1st only secured: add 1 m. 4·6 s. as seen in the table of the sun's semidiameter for October 2nd, and you have the same result as the centre, or the mean of all three observations, which is 11 h. 49 m. 30·1 s.

Time shown by Watch or Chronometer.

		H.	M.	S.	
1st Observation . .		11	48	25·5	
2nd ditto . . .		11	49	30·1	
3rd ditto . . .		11	50	34·7	
	3)	35	28	30·3	
		11	49	30·1	Mean of the whole.

The above is all the calculation necessary to ascertain the time to within a fraction of a second. It is seen that, by adding the first and third observations together, and dividing by two, the mean result gives the same as the second observation, or the time shown by the chronometer at the instant when the two suns coincided; and if we add all the three observations together, and divide by three (according to the latter example),we then obtain, as the mean of the whole, 11 h. 49 m. 30.1 s.; which result, corresponds with the time stated in the table for the Equation of time, as that which should be indicated by the watch or chronometer, at apparent or solar noon, for that day. If the watch or chronometer show the time *less* than in the table, it is *too slow;* if more, it is *too fast.* The most perfect observations will always be obtained from the touching and separation of the sun's edges; as it is difficult, when taking the second observation, to determine the exact moment of coincidence.

While the advantage of the Dipleidoscope is such as not to be limited to a few degrees of latitude necessary to observe the sun's highest and lowest altitude, and is of sufficient extent for all England and most parts of Europe; still, when the instrument is required for such low latitudes as India, the Dipleidoscope can be made suitable for all places so near to the equator.

EFFECT OF LONGITUDE ON TIME.

The observer being supposed to have fixed his instrument, according to the foregoing directions, is now in possession of the Dover time; but, in order to familiarize him with the differences produced by variety of longitudes, it may be desirable to state two imaginary cases: for the one we will take Dover, which is East of Greenwich; and, for the other, say Birmingham, which is West. The watch or chronometer in the supposed instance before us, we must remember, exhibits Dover time.

Now, if the hour of departure of a rail-road train from Dover be regulated by the directors according to *London time* (say Greenwich time, as, I believe, is generally the custom), the following correction should be made by the party who may desire that his time should coincide with theirs. The time shown by the forementioned experiment, made the watch or chronometer, on the 2nd of October, 11 h. 49 m. 30·1 s. which was equivalent to mean noon, or twelve o'clock of that day, *at Dover*. Now, as Dover is East of Greenwich 5 m. 16 s., the time indicated by the watch or chronometer for Dover will be exactly that quantity too fast for the *railroad* or *Greenwich* time.

To take the opposite case;—should we suppose the instrument to be fixed, and the mean time ascertained at Birmingham, which is *west* of Greenwich 7 m. 33 s., the party, reckoning by this calculation, which gives the Birmingham time, would be too late for the London train by 7 m. 33 s., that being the difference in time between the meridians of the two places specified.* In the latitude of London 947 feet is equal to one second of time: of course, the direction is to be due East or West.

By furnishing these few accompanying instructions, the writer trusts that he has succeeded fully in placing before the public a "cheap, simple, and correct meridian-instrument, requiring little or no scientific knowledge for its right use, and not readily susceptible of injury or derangement."

Postscript.

The origin of the Dipleidoscope resulted from the following circumstances. The writer had long felt persuaded that the interests of Horology would be promoted if the public were more generally possessed of a cheap, simple, and correct transit-instrument, requiring little or no scientific knowledge for its right use, and not readily susceptible of injury or derangement. To this end he had devoted much time and thought; and, in 1840, he considered that he had succeeded in inventing an apparatus which, by means of *shadows*, would produce the desired result. This idea

* For further information, see DENT'S Lectures.

he communicated to J. M. Bloxam, Esq., who thereupon informed him that his own attention had been forsome years devoted to the same object, and that he had contrived an optical arrangement, which, by the agency of a single and double reflection, determined the sun's passage over the meridian with great exactness. When the optical instrument, although complicate in its then form, was shown to the writer, he was immediately struck with the superiority of the contrivance over that which had suggested itself to *him:* his own method afforded three observations, but it was attended with the defects and inconvenience which result from the uncertainty of shadows.

Convinced that the reflecting planes would effectually accomplish the desired end, he entered into an arrangement with Mr. Bloxam to undertake their manufacture; and, after nearly two years' attention on the part of that gentleman, and at great labour and expense on the part of the proposer, they are now respectfully presented to the public in the present simple, but most accurate form. The writer, to secure his property in the instrument, as well as to insure its future perfect manufacture, solicited the favour of Mr. Bloxam to take out a patent in his own name, at the expense of the manufacturer, and, for a certain consideration, to transfer all interest in the invention to him. This request was kindly acceded to, and accordingly the Dipleidoscope, as an article of commerce, bears on it the name of the maker and proprietor, E. J. Dent.

DENT'S APPROXIMATE TABLE

FROM THE MERIDIAN

ENGLAND.

Names of Counties and Towns.	Time of Place, Fast or Slow of Mean Time at Greenwich.			
	M.	S.		
BEDFORDSHIRE—				
Bedford	1	52	West.	Slow.
Leighton Buzzard	2	39	,,	,,
BERKSHIRE—				
Abingdon	5	7	,,	,,
Windsor	2	22	,,	,,
BUCKINGHAMSHIRE—				
Buckingham	3	57	,,	,,
Aylesbury	3	21	,,	,,
CAMBRIDGESHIRE—				
Cambridge	0	23	East.	Fast.
Ely	1	4	,,	,,
CHESHIRE—				
Chester	11	32	W.	Slow.
Macclesfield	8	30	,,	,,
CORNWALL—				
Falmouth	20	12	,,	,,
Truro	20	6	,,	,,
CUMBERLAND—				
Carlisle	11	38	,,	,,
Penrith	10	56	,,	,,
DERBYSHIRE—				
Derby	5	52	,,	,,
Chesterfield	5	40	,,	,,
DEVONSHIRE—				
Exeter	14	18	,,	,,
Plymouth	16	30	,,	,,
DORSETSHIRE—				
Dorchester	9	43	,,	,,
Bridport	11	24	,,	,,
DURHAM—				
Durham	6	16	,,	,,
Darlington	6	12	,,	,,
ESSEX—				
Colchester	3	32	E.	Fast.
Maldon	2	42	,,	,,
Chelmsford	1	52	,,	,,
GLOUCESTERSHIRE—				
Gloucester	8	58	W.	Slow.
Cheltenham	8	16	,,	,,
HAMPSHIRE—				
Southampton	5	36	,,	,,
Portsmouth	4	24	,,	,,
HEREFORDSHIRE—				
Hereford	10	52	,,	,,
Leominster	10	54	,,	,,
HERTFORDSHIRE—				
Hertford	0	16	,,	,,
Tring	2	38	,,	,,
HUNTINGDONSHIRE—				
Huntingdon	0	45	,,	,,
Kimbolton	1	37	,,	,,
KENT—				
Greenwich Royal Observatory	0	0	0	
Dover	5	16	E.	Fast.
Tunbridge Wells	1	1	,,	,,
LANCASHIRE—				
Lancaster	11	10	W.	Slow.
Manchester	9	0	,,	,,
Liverpool	11	53	,,	,,
LEICESTERSHIRE—				
Leicester	4	33	,,	,,
Melton Mowbray	3	33	,,	,,
LINCOLNSHIRE—				
Lincoln	2	4	,,	,,
Louth	0	0	0	
MIDDLESEX—				
St. Paul's	0	23	,,	,,
MIDDLESEX, *continued*—				
82, Strand	0	28·7	West.	Slow.
St. James's Church, Piccadilly	0	32·3	,,	,,
Hampton Court	1	20	,,	,,
MONMOUTHSHIRE—				
Monmouth	10	48	,,	,,
Abergavenny	12	0	,,	,,
NORFOLK—				
Norwich	5	12	East.	Fast.
Fakenham	3	24	,,	,,
NORTHAMPTONSHIRE—				
Northampton	3	36	W.	Slow.
Peterborough	0	58	,,	,,
NORTHUMBERLAND—				
Alnwick	6	48	,,	,,
Newcastle	6	24	,,	,,
NOTTINGHAMSHIRE—				
Nottingham	4	41	,,	,,
Retford	3	25	,,	,,
OXFORDSHIRE—				
Oxford	5	1	,,	,,
Chipping Norton	6	12	,,	,,
RUTLANDSHIRE—				
Oakham	3	20	,,	,,
SHROPSHIRE—				
Shrewsbury	10	56	,,	,,
Oswestry	12	8	,,	,,
SOMERSETSHIRE—				
Taunton	12	21	,,	,,
Bath	9	26	,,	,,
STAFFORDSHIRE—				
Stafford	8	40	,,	,,
Lichfield	7	18	,,	,,
Tamworth	6	49	,,	,,
SUFFOLK—				
Ipswich	4	38	E.	Fast.
Bury St. Edmund's	2	53	,,	,,
SURREY—				
Guildford	2	18	W.	Slow.
Croydon	0	26	,,	,,
SUSSEX—				
Brighton	0	32	,,	,,
Hastings	2	20	E.	Fast.
WARWICKSHIRE—				
Warwick	6	20	W.	Slow.
Birmingham	7	33	,,	,,
Coventry	6	1	,,	,,
WESTMORELAND—				
Kendal	11	0	,,	,,
Appleby	10	0	,,	,,
WILTSHIRE—				
Marlborough	6	53	,,	,,
Devizes	7	55	,,	,,
WORCESTERSHIRE—				
Worcester	8	41	,,	,,
Kidderminster	8	58	,,	,,
YORKSHIRE—				
Beverley	1	42	,,	,,
York	4	24	,,	,,
Leeds	6	4	,,	,,
NORTH WALES—				
Holyhead	18	36	,,	,,
Bangor	16	14	,,	,,
SOUTH WALES—				
Cardigan	18	40	,,	,,
Carmarthen	17	16	,,	,,

OF LONGITUDES IN TIME,

OF GREENWICH.

SCOTLAND.

Name of Place.	Slow of Mean Time at Greenh. M.	S.	Name of Place.	Slow of Mean Time at Greenh. M.	S.
Aberdeen	8	23	Inverurie	10	24
Abernethy	14	34	Jedburgh	10	22
Annan	12	56	Kilmar	17	52
Arbroath	10	20	Kinross	13	44
Berwick on Tweed	8	0	Kirkcudbright	16	0
North Berwick	10	56	Lanark	15	12
Cromarty	16	0	Langholm	11	46
Culross	14	36	Montrose	9	54
Dumbarton	18	8	Newburg	13	2
Dumfries	14	16	Peebles	12	44
Dunbar	10	4	Perth	13	44
Dundee	12	8	Rothsay	19	56
Edinburgh	12	43	St. Andrews	11	22
Fraserburgh	8	16	Selkirk	11	18
Glasgow	17	0	Stirling	15	46
Haddington	11	6	Stonehaven	9	0
Huntly	11	20	Stranraer	19	40
Inverary	20	4	Thurso	14	20
Inverness	16	46	Wigtown	17	24

IRELAND.

Name of Place.	Slow of Mean Time at Greenh. M.	S.	Name of Place.	Slow of Mean Time at Greenh. M.	S.
Armagh	26	35	Londonderry	29	4
Belfast	23	34	Longford	31	0
Carlow	27	40	Louth	26	8
Carrick	32	12	Maryborough	29	8
Castlebar	36	58	Monaghan	27	40
Cavan	29	4	Mullingar	29	12
Clare	35	44	Omagh	29	0
Cork	33	56	Philipstown	29	16
Donegal	32	10	Roscommon	32	34
Downpatrick	22	44	Sligo	33	38
Dublin	25	22	Tipperary	32	32
Enniskillen	30	12	Tralee	38	38
Galway	36	0	Trim	27	6
Kildare	27	40	Waterford	28	30
Kilkenny	28	56	Wexford	25	36
Limerick	34	8	Wicklow	24	6

FOREIGN PLACES.

Name of Place.	Time of Place, Fast or Slow of Mean Time at Greenwich. H.	M.	S.	
Amsterdam	0	19	26·0	E. Fast.
Berlin	0	53	35·3	,,
Bombay	4	51	38·0	,,
Brussels	0	17	29·0	,,
Cadiz	0	25	9·0	W. Slow.
Calcutta	5	53	52·0	E. Fast.
Canton	7	33	4·0	,,
Constantinople	1	55	40·0	,,
Copenhagen	0	50	19·8	,,
Frankfort	0	34	23·0	,,
Geneva	0	24	37·5	W. Slow.
Madrid	0	14	34·0	,,
Marseilles	0	21	29·0	E. Fast.
Naples	0	57	0·3	,,
Paris	0	9	21·28	,,
Rome	0	49	54·7	,,
St. Petersburg	2	1	15·8	,,
Strasburg	0	31	0·8	,,
Turin	0	30	48·4	,,
Vienna	1	5	31·9	,,

DENT'S TABLE FOR THE

To accompany his New

This Table shows the Time which a Clock or Watch should indicate when the Sun is on the meridian, and the difference is its error.

THIS TABLE IS DEDUCED FROM THE NAUTICAL

Day of Month.	January.			February.			March.			April.			May.			June.		
	H.	M.	S.	H.	M.	S.	H.	M.	S.	H.	M.	S.	H.	M.	S.	H.	M.	S.
1	12	3	56·9	12	13	55·9	12	12	34·7	12	3	56·2	11	56	56·7	11	57	28·7
2	„	4	25·1	„	14	3·2	„	12	22·4	„	3	38·1	„	56	49·4	„	57	37·9
3	„	4	53·0	„	14	9·8	„	12	9·7	„	3	20·1	„	56	42·7	„	57	47·5
4	„	5	20·4	„	14	15·6	„	11	56·6	„	3	2·3	„	56	36·6	„	57	57·5
5	„	5	47·5	„	14	20·5	„	11	43·0	„	2	44·7	„	56	31·1	„	58	7·8
6	„	6	14·1	„	14	24·6	„	11	28·9	„	2	27·2	„	56	26·1	„	58	18·4
7	„	6	40·2	„	14	28·0	„	11	14·5	„	2	10·0	„	56	21·6	„	58	29·4
8	„	7	5·9	„	14	30·5	„	10	59·7	„	1	53·0	„	56	17·8	„	58	40·7
9	„	7	31·0	„	14	32·3	„	10	44·5	„	1	36·2	„	56	14·5	„	58	52·2
10	„	7	55·6	„	14	33·2	„	10	28·9	„	1	19·7	„	56	11·7	„	59	3·9
11	„	8	19·5	„	14	33·4	„	10	13·0	„	1	3·4	„	56	9·6	„	59	15·9
12	„	8	42·9	„	14	32·7	„	9	56·8	„	0	47·4	„	56	7·9	„	59	28·0
13	„	9	5·6	„	14	31·3	„	9	40·3	„	0	31·7	„	56	6·9	„	59	40·3
14	„	9	27·6	„	14	29·1	„	9	23·5	„	0	16·3	„	56	6·4	„	59	52·8
15	„	9	49·0	„	14	26·2	„	9	6·4	„	0	1·2	„	56	6·4	12	0	5·3
16	„	10	9·6	„	14	22.5	„	8	49·1	11	59	46·5	„	56	7·0	„	0	18·0
17	„	10	29·6	„	14	18·1	„	8	31·5	„	59	32·1	„	56	8·2	„	0	30·7
18	„	10	48·8	„	14	13·0	„	8	13·8	„	59	18·1	„	56	9·9	„	0	43·6
19	„	11	7·2	„	14	7·2	„	7	55·8	„	59	4·4	„	56	12·1	„	0	56·4
20	„	11	24·9	„	14	0·7	„	7	37·7	„	58	51·2	„	56	14·9	„	1	9·3
21	„	11	41·9	„	13	53·5	„	7	19·5	„	58	38·4	„	56	18·2	„	1	22·2
22	„	11	58·0	„	13	45·7	„	7	1·1	„	58	26·0	„	56	22·1	„	1	35·0
23	„	12	13·4	„	13	37·3	„	6	42·6	„	58	14·1	„	56	26·5	„	1	47·9
24	„	12	28·0	„	13	28·2	„	6	24·1	„	58	2·6	„	56	31·4	„	2	0·6
25	„	12	41·7	„	13	18·6	„	6	5·5	„	57	51·7	„	56	36·8	„	2	13·3
26	„	12	54·7	„	13	8·4	„	5	46·9	„	57	41·2	„	56	42·8	„	2	26·0
27	„	13	6·9	„	12	57·7	„	5	28·3	„	57	31·2	„	56	49·2	„	2	38·4
28	„	13	18·3	„	12	46·5	„	5	9·8	„	57	21·8	„	56	56·2	„	2	50·8
29	„	13	28·9				„	4	51·3	„	57	12·9	„	57	3·6	„	3	2·9
30	„	13	38·7				„	4	32·8	„	57	4·5	„	57	11·5	„	3	14·9
31	„	13	47·7				„	4	14·5				„	57	19·9			

EQUATION OF TIME, 1845.

Patent Meridian Instrument.

EXAMPLE.

		H.	M.	S.
1845. July 1.	Time shown by Clock or Watch when the Sun was on the meridian	12	4	39·2
	Time by Table	12	3	26·7
	Clock or Watch too fast . .	0	1	12·5

ALMANACK FOR THE MERIDIAN OF GREENWICH.

Day of Month	July.			August.			September.			October.			November.			December.		
	H.	M.	S.	H.	M.	S.	H.	M.	S.	H.	M.	S.	H.	M.	S.	H.	M.	S.
1	12	3	26·7	12	6	0·3	11	59	49·8	11	49	38·7	11	43	43·3	11	49	17·9
2	„	3	38·2	„	5	56·5	„	59	31·0	„	49	19·9	„	43	42·6	„	49	41·0
3	„	3	49·5	„	5	52·2	„	59	11·9	„	49	1·4	„	43	42·6	„	50	4·7
4	„	4	0·5	„	5	47·3	„	58	52·6	„	48	43·2	„	43	43·5	„	50	29·1
5	„	4	11·2	„	5	41·7	„	58	33·0	„	48	25·4	„	43	45·2	„	50	53·9
6	„	4	21·5	„	5	35·6	„	58	13·1	„	48	7·9	„	43	47·7	„	51	19·3
7	„	4	31·4	„	5	28·9	„	57	53·0	„	47	50·8	„	43	51·0	„	51	45·2
8	„	4	41·0	„	5	21·5	„	57	32·8	„	47	34·1	„	43	55·1	„	52	11·6
9	„	4	50·2	„	5	13·6	„	57	12·3	„	47	17·8	„	44	0·1	„	52	38·4
10	„	4	58·9	„	5	5·0	„	56	51·7	„	47	2·0	„	44	5·8	„	53	5·6
11	„	5	7·2	„	4	55·9	„	56	30·9	„	46	46·6	„	44	12·4	„	53	33·2
12	„	5	15·1	„	4	46·2	„	56	10·0	„	46	31·7	„	44	19·9	„	54	1·2
13	„	5	22·4	„	4	35·9	„	55	49·0	„	46	17·2	„	44	28·2	„	54	29·5
14	„	5	29·3	„	4	25·0	„	55	27·9	„	46	3·3	„	44	27·3	„	54	58·1
15	„	5	35·7	„	4	13·6	„	55	6·7	„	45	49·9	„	44	47·3	„	55	27·0
16	„	5	41·5	„	4	1·7	„	54	45·5	„	45	37·1	„	44	58·1	„	55	56·2
17	„	5	46·8	„	3	49·3	„	54	24·3	„	45	24·9	„	45	9·8	„	56	25·6
18	„	5	51·6	„	3	36·3	„	54	3·1	„	45	13·2	„	45	22·3	„	56	55·1
19	„	5	55·9	„	3	22·8	„	53	42·0	„	45	2·2	„	45	35·7	„	57	24·8
20	„	5	59·6	„	3	8·9	„	53	20·9	„	44	51·9	„	45	49·9	„	57	54·7
21	„	6	2·8	„	2	54·5	„	52	59·9	„	44	42·2	„	46	4·9	„	58	24·7
22	„	6	5·4	„	2	39·6	„	52	38·9	„	44	33·1	„	46	20·7	„	58	54·7
23	„	6	7·5	„	2	24·3	„	52	18·1	„	44	24·8	„	46	37·4	„	59	24·8
24	„	6	9·0	„	2	8·6	„	51	57·5	„	44	17·2	„	46	54·8	„	59	54·8
25	„	6	9·9	„	1	52·5	„	51	37·0	„	44	10·3	„	47	13·1	12	0	24·8
26	„	6	10·3	„	1	36·1	„	51	16·7	„	44	4·2	„	47	32·1	„	0	54·7
27	„	6	10·1	„	1	19·2	„	50	56·6	„	43	58·8	„	47	51·8	„	1	24·5
28	„	6	9·3	„	1	2·0	„	50	36·7	„	43	54·1	„	48	12·3	„	1	54·2
29	„	6	7·9	„	0	44·4	„	50	17·1	„	43	50·2	„	48	33·5	„	2	23·6
30	„	6	5·9	„	0	26·5	„	49	57·8	„	43	47·1	„	48	55·3	„	2	52·8
31	„	6	3·4	„	0	8·3				„	43	44·8				„	3	21·8

TIME OF THE SUN'S SEMI-DIAMETER PASSING THE MERIDIAN.

N.B.—The Time for any Day omitted in the Table is the same as for the Day next preceding.

1845.

DATE. Jan.	M.	S.	DATE. Feb.	M.	S.	DATE. May.	M.	S.	DATE Aug.	M.	S.	DATE. Oct.	M.	S.
1	1	10·8	21	1	5·8	17	1	7·1	8	1	5·8	30	1	6·5
2	1	10·7	22	1	5·7	18	1	7·2	9	1	5·7	31	1	6·6
4	1	10·6	23	1	5·6	19	1	7·3	10	1	5·6	Nov.		
6	1	10·5	25	1	5·5	21	1	7·4	11	1	5·5	1	1	6·7
7	1	10·4	26	1	5·4	22	1	7·5	13	1	5·4	2	1	6·8
9	1	10·3	27	1	5·3	23	1	7·6	14	1	5·3	3	1	6·9
10	1	10·2	28	1	5·2	25	1	7·7	15	1	5·2	4	1	7·1
11	1	10·1	Mar.			26	1	7·8	17	1	5·1	5	1	7·2
13	1	10·0	2	1	5·1	28	1	7·9	18	1	5·0	6	1	7·3
14	1	9·9	3	1	5·0	29	1	8·0	19	1	4·9	7	1	7·4
15	1	9·8	5	1	4·9	31	1	8·1	21	1	4·8	8	1	7·5
16	1	9·7	6	1	4·8	June.			22	1	4·7	9	1	7·6
17	1	9·6	8	1	4·7	2	1	8·2	24	1	4·6	10	1	1·8
18	1	9·5	10	1	4·6	4	1	8·3	25	1	4·5	11	1	7·9
19	1	9·4	12	1	4·5	6	1	8·4	27	1	4·4	12	1	8·0
20	1	9·3	14	1	4·4	8	1	8·5	29	1	4·3	13	1	8·1
21	1	9·2	17	1	4·3	11	1	8·6	31	1	4·2	14	1	8·2
22	1	9·1	21	1	4·2	15	1	8·7	Sept.			15	1	8·4
23	1	9·0	Apr.			26	1	8·6	2	1	4·1	16	1	8·5
24	1	8·9	2	1	4·3	30	1	8·5	5	1	4·0	17	1	8·6
25	1	8·8	6	1	4·4	July.			8	1	3·9	18	1	8·7
26	1	8·7	9	1	4·5	3	1	8·4	14	1	3·8	19	1	8·8
27	1	8·6	12	1	4·6	5	1	8·3	21	1	3·9	20	1	8·9
28	1	8·4	14	1	4·7	7	1	8·2	26	1	4·0	21	1	9·0
29	1	8·3	16	1	4·8	9	1	8·1	30	1	4·1	22	1	9·1
30	1	8·2	18	1	4·9	11	1	8·0	Oct.			23	1	9·3
31	1	8·1	19	1	5·0	13	1	7·9	2	1	4·2	24	1	9·4
Feb.			21	1	5·1	14	1	7·8	4	1	4·3	25	1	9·5
1	1	8·0	22	1	5·2	16	1	7·7	6	1	4·4	26	1	9·6
2	1	7·9	24	1	5·3	17	1	7·6	8	1	4·5	27	1	9·7
3	1	7·7	25	1	5·4	18	1	7·5	9	1	4·6	28	1	9·8
4	1	7·6	27	1	5·5	20	1	7·4	11	1	4·7	29	1	9·9
5	1	7 5	28	1	5·6	21	1	7·3	12	1	4·8	Dec.		
6	1	7·4	29	1	5·7	22	1	7·2	13	1	4·9	1	1	10·0
7	1	7·3	May.			23	1	7·1	15	1	5·0	2	1	10·1
8	1	7·2	1	1	5·8	25	1	7·0	16	1	5·1	3	1	10·2
9	1	7·1	2	1	5·9	26	1	6·9	17	1	5·2	4	1	10·3
10	1	7·0	3	1	6·0	27	1	6 8	18	1	5·3	5	1	10·4
11	1	6·8	5	1	6·1	28	1	6·7	19	1	5·4	7	1	10·5
12	1	6·7	6	1	6·2	29	1	6·6	20	1	5·5	8	1	10·6
13	1	6·6	7	1	6·3	31	1	6·5	22	1	5·6	10	1	10·7
14	1	6·5	8	1	6·4	Aug.			23	1	5·7	12	1	10·8
15	1	6·4	10	1	6·5	1	1	6·4	24	1	5·8	14	1	10·9
16	1	6·3	11	1	6·6	2	1	6·3	25	1	5·9	17	1	11·0
17	1	6·2	12	1	6·7	3	1	6·2	26	1	6·1	28	1	10·9
18	1	6·1	13	1	6·8	4	1	6·1	27	1	6·2	31	1	10·8
19	1	6·0	14	1	6·9	5	1	6·0	28	1	6·3			
20	1	5·9	16	1	7·0	7	1	5·9	29	1	6·4			

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